

Home Monitoring and Personal Health Management Services in a Regional Health Telematics Network

A. Traganitis^{1,2}, D. Trypakis², M. Spanakis², S. Condos³, T. Stamkopoulos³, M. Tsiknakis²,
and S. C. Orphanoudakis^{1,2}

¹Department of Computer Science, University of Crete, Heraklion, Crete, Greece

²Institute of Computer Science, Foundation for Research and Technology-Hellas, Heraklion, Crete, Greece

³Office of Telemedicine, School of Medicine, Yale University, USA

Abstract - This paper describes the architectural considerations of HYGEIANet (the Regional Health Telematics Network of Crete), the R&D issues involved in the design, development and implementation of a modular and configurable Home Care Platform that supports different health and social care domains, and the results of the clinical pilots to evaluate the platform and the service. In addition, the R&D issues that must be addressed in order to transform and extend the aforementioned platform for the support of personal health management services will be presented.

Keywords - Health Care, Home Care, Behavioural Telemedicine, Telemonitoring and Telemanagement.

I. INTRODUCTION

Information and Communication Technologies (ICT) are currently revolutionising the practice of health care. Another important force for change is the search for cost containment, combined with a need to improve quality of care and access to care.

With increasing life expectancy and changing life styles disease patterns are also changing. At the same time, citizens are becoming better educated and informed. Thus, their expectations and demands from the health system are increasing.

As a result, the practice of health and social care is undergoing fundamental changes. The traditional hierarchical care delivery structures (from primary to secondary, tertiary and university hospital level care) are becoming flat, i.e. health care delivery is shifted to the periphery [1] and part of the responsibility of care is transferred to the citizens and patients themselves (wellness or health maintenance). This change in health care delivery, from institution-centred towards citizen-centred care [2], has been ongoing for several years and has undergone several paradigm shifts, as shown in Fig. 1.

This paper describes the architectural considerations of HYGEIANet, the Regional Health Telematics Network of Crete, the R&D issues involved in the design, development and implementation of a modular and configurable Home Care Platform (HCP) that supports different health and social care domains, the design of the clinical pilots used to evaluate the platform and the service, as well as the R&D issues that need to be resolved in order to transform and extend the home care platform so that it may support personal health management services.

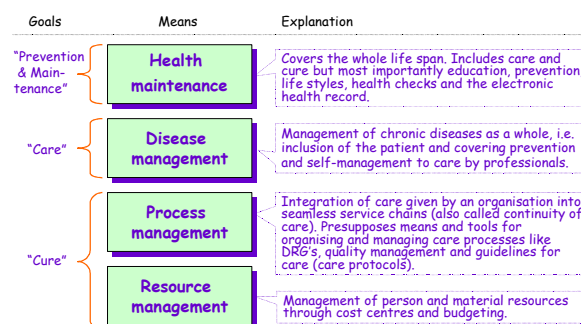


Fig. 1: Evolution of the concept of health care from institution centred thinking to health maintenance in partnership with the individual and health professionals

The context

The development of the Integrated Regional Health Telematics Network of Crete, shown in Fig. 2, represent a systematic effort to provide an integrated environment for healthcare delivery and medical training across the island.

In the course of designing HYGEIANet, special efforts have been made to meet the requirements of the user groups involved and to use state-of-the-art technology and standards in every aspect of the system. Alternative patient-, problem-, and case-oriented architectures for the Integrated Electronic Health Record (I-EHR)[3] have been considered in an attempt to provide transparent access and secure transmission of information between and within medical specialty areas, as well as in a variety of situations.

An important application domain within HYGEIANet is Home Care. In addition to clinical and other factors stated above, the geographical and demographic diversity of Crete necessitates the provision of home care delivery from community to hospital care across the region.



Fig. 2: HYGEIANet, the integrated Health Telematics Network of Crete (www.HYGEIANet.gr)

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II. METHODOLOGY

The Home Care Platform has been designed as a modular platform to allow for its easy customization and adaptation to the requirements of the various clinical scenarios, supporting the telemonitoring and telemanagement of patients by a distant expert.

The various homecare service scenarios envisaged can be enabled with two different policies: a) scheduled meetings, where the sessions take place at scheduled times [4]; b) continuous support, where any session can be activated during the hours of service provision (eventually 24 hours a day). The technical validation of the platform has been performed in a service scenario supporting the telemanagement of children with asthma.

Working with users and service providers, the following operating procedure was set up: a) connection to the service provider (hospital), when the patient is the session activator, or connection to a specific patient, when the service provider is the session activator; b) acceptance of a connection request; c) description of the problem by the patient; d) call for the assistance of a doctor, if necessary; e) observation of the patient with a video camera; f) acquisition of measurements with the help of specific medical sensors; g) provision of medical advice and modification of the treatment according to the new patient data; h) termination of the session and persistent management of data acquired, communicated and/or generated.

Videoconference was considered necessary to be compliant with the requirement to provide multimedia support in order to guide the patient in assisting with the medical examinations. Furthermore, it provides the means for exchanging additional information and medical advice easily between patient and doctor and to provide psychological support [5] for the patient, especially in situations of social care.

The part of the platform on the home side is connected to the existing broadband communication infrastructure of HYGEIAnet through either a fixed or a wireless connection. The overall architecture of the HCP is diagrammatically shown in Fig. 3.

The HCP was developed as a distributed computing environment, able to support real-time transmission of video images and medical vital signs through standard Internet protocols.

On the Health Call Centre (HCC) side, a physician can use videoconference and various medical sensors that are attached to the patient's part of the platform. The nurse/physician has full control of the HCP, including the attached medical devices.

Dedicated software components have been developed allowing the acquisition of clinical data from the various medical devices connected to the platform, as well as the real-time transmission of the acquired medical data over IP networks.

The communication is based on a control channel activated immediately after a connection. Using this main

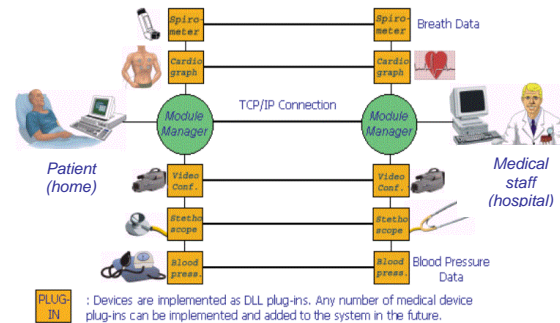


Fig. 3: Architecture of the Home Care Platform

control channel, information about the existing medical devices installed in the connected HCP is transferred to the HCC and automatically displayed on the physician's screen. The physician is able to activate and control all the medical devices. Once activated, each device has its own control channel, which is used to transfer commands or status information between the two sides. Also, a specific data channel is activated for real-time transmission of the medical data.

An important architectural consideration was the platform modularity, to allow for its easy extension, with the addition of medical devices necessary in other clinical domains, as required. A template for a generic medical device with all the necessary methods for exchanging commands and data through the network was designed and developed. The addition of a new medical device requires only the mapping of the device-specific characteristics to the abstracted and generic template.

Different types of prototypical medical devices have been designed and developed, such as an electronic stethoscope and a cardiograph, while a number of commercial medical devices have also been integrated in the HCP. Several of these medical devices are briefly described below.

Electronic Stethoscope – On the patient's side it is necessary to acquire a sound signal, send it through the network and present it to the physician with a quality comparable to the signal obtained through a conventional high quality stethoscope. A common stethoscope was used, fitted with a microphone, connected to the microphone-input of a soundcard. The real-time process acquires the input signal, packetizes and compresses data for transmission through the network to a remote physician. There, the incoming data are decompressed, filtered and sent to the line-out port of a soundcard, to which an earphone, constructed with part of a conventional stethoscope, is attached [6]. Different kinds of FIR band pass filters can be employed: a) for the lungs there is a choice of filters for hearing the high frequencies (Diaphragm) or the even higher frequencies (Extended Diaphragm), and b) for the heart the physician can use a low frequency filter (Bell). These filters have been designed and tested extensively in order to come up with the best corner frequencies [7]. The physician can choose the desired filter through an appropriate user interface element, shown in Fig. 4, which appears after the launching of the stethoscope.



Fig. 4: The Electronic Stethoscope of the HCP

Electrocardiograph - The ECG signal is amplified and filtered by an analogue input unit and then is applied by inductive coupling to the line input of the audio card. It is digitized, compressed, packetized and transmitted to the physician [8]. The incoming data are depacketised and decompressed and the ECG signal is displayed on the physician's monitor. The protocol works in real-time and the doctor is able, using this device, to monitor the patient's heartbeat for as long as necessary (see Fig. 5).

Electronic Scale - An electronic scale is necessary in a variety of clinical cases requiring the measurement of the body weight or the weight of the exchanged liquids during a Continuous Ambulatory Peritoneal Dialysis (CAPD) session being telemonitored at home. Dedicated software was developed to allow the remote control (operated by experts) of the electronic scale.

Peak Flow Meter (PEF) - This device is used by the expert in the case of asthma for the measurement of the maximum expiratory flow rate as an aid to assessing lung function. In the experimental phase on paediatric asthma, this device is used at the patient's home but it is not directly integrated in the HCP. The patient assisted by the physician performs a measurement and communicates the result by reading it to the physician. Work is currently underway for the integration of a PEF device in the HCP.

Spirometer - In respiratory diseases, pathological changes occur predominantly in the smaller airways, which necessitate the use of a spirometer for measuring the lung volumes. For this reason, a spirometer is currently been integrated in the HCP.

Remotely Controlled Camera - Dedicated software was also developed to allow the remote control of the camera, by transferring user commands over the network. Experimental results have shown that the camera's response to the remote user's request is very satisfactory.



Fig. 5: The Electrocardiograph of the HCP

III. RESULTS

The home care platform has been deployed in the context of HYGIEAnet as a modular platform able to support home care services in different clinical and social domains. The software architecture of the overall system is easily configurable to support different patient groups and is easily upgraded with the integration of additional medical devices to the core platform.

An initial technical evaluation study was conducted to assess the platform's operational characteristics under real life conditions. Issues such as required bandwidth for optimal performance, robustness, ease of use, and real time performance were evaluated. The results obtained reveal that the platform exhibits characteristics that prove its usefulness and effectiveness for the follow up monitoring of patients with chronic diseases from a distance. Specifically, a 128 kbps channel was found to be quite satisfactory, and also the overall auscultation quality of the stethoscope was found to be at 70-80% compared with a direct auscultation, as reported by a number of medical professionals consulted on the matter.

In addition, extended clinical trials were conducted over HYGIEAnet for evaluating the clinical effectiveness of the platform for telemanagement of patients with paediatric asthma. This study was performed, along with similar studies in other European Regions, within the EC funded programme ATTRACT. Medical history, physical examination of patients, review of medications, directions for on-going treatment and, in some cases, rescue treatment for exacerbations of disease were done via the developed Home Care Platform. The evaluation of clinical results reveals the effectiveness of the platform, as reported in detail in ref. [9]. Specifically, the results reported in [9] suggest a relatively high rate of health improvement, and can therefore be considered as strong evidence for the effectiveness and efficiency of the HCP in supporting the delivery of teleservices to citizen's with chronic diseases.

IV. DISCUSSION

The clinical pilots done in the context of HYGIEAnet, in providing home care services, proved that telemedicine can offer a substantial service if used in the right medical and social context.

At the same time, the traditional hierarchical care delivery structures (from primary to secondary, tertiary and university hospital level care) are becoming flat, i.e. health care delivery is shifted to the periphery [1] and part of the responsibility of care is transferred to the citizens and patients themselves (wellness or health maintenance). Health education offers the citizen a mass of information about risk factors, but this seldom leads to permanent life style change, which is a prerequisite for lowering the personal risk. Permanent change requires personal management of the key risk factors. Such a need necessitates the development of novel technological platforms and services to support individuals in been

personally responsible for their health and well being. There is already significant work taking place in trying to develop Personal Health Management and Behavioural Telemedicine Systems [10].

The requirements for personal management of health risks are: (a) provision of adequate information about risks, their causes and effects; (b) accurate mapping of the current status and related factors; (c) proper understanding of information in the context of a person's own life style and current health status; (d) continuous integration of planning and follow-up for risk factor management; and (e) provision of continuous feedback and positive reinforcement to support the management. In achieving this feedback, technological components are currently been developed within the context of HYGEIAnet allowing for the (a) monitoring of health related data; (b) long term management of data in the appropriate segment of the citizen's Integrated Electronic Health Record (I-EHR) or, interfaced with I-HER; (c) processing of the data (from measured data to information about health and trends in well-being); (d) feedback (visualisation of the health data combined with relevant guidelines and additional information).

V. CONCLUSION

The preliminary results of large-scale clinical pilots indicate that telemedicine can offer a substantial service if used in the right medical or social context. It can be safely used (together with traditional care) for chronic patients in long-term follow up care and management. It has not yet been tried for the diagnosis and initial evaluation of new patients. It is ideal for offering service to patients/persons living in isolated, distant or disadvantaged areas. If telemedicine eliminates the distance, then the quality care of people will become easier and maintaining medical or mental health will be easier and more effective. If used properly, in addition to providing quality care, additional gains from telecare could be achieved such as fewer emergency room visits, fewer hospital admissions, lower cost of disease, less traffic on the roads, better quality of life and better environment.

At the same time, health care consumers are undergoing a radical metamorphosis. They are becoming engaged, empowered, energized e-Health consumers. They represent a large force that is about to transform the health care world. These emerging e-Health consumers know more, expect more, and demand more – all along the health care continuum.

These pressing user requirements necessitate rapid technological developments to be made, in coupling the development of wellness pathways, ambient intelligence technologies and hence an intelligent home environment, with an advanced trust infrastructure, biofeedback and personalized information delivery to support interactive

social care as well as wellness and disease management services. Personal health management is achieved through the integration of various feedback mechanisms, which have different time scale, frequency of usage, and level of integration to health care services.

We are currently involved in an R&D effort to extend the HCP technological platform presented in this paper into an innovative advanced personal health management platform.

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